PATENT SPECIFICATION 679,514

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COMPLETE SPECIFICATION.

Improvements in or relating to the Manufacture of Electric Battery Separators.

We, YOUNG ACCUMULATOR COMPANY LIMITED, a British Company, of Burlington Works, Malden Way, New Malden, Surrey, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement :—

This invention is concerned with improvements in or relating to the manufacture of separators for electric storage batteries.

Separators between the positive and negative plates of storage batteries have been made of wood which whilst satisfactory in some respects, tends to dry out, shrink or crack and causes damage to the plates if the battery is stored in a dry condition. Separators of rubber, and various plastic substances have been proposed to overcome this disadvantage and whilst they are not so liable to damage the plates, they suffer from the disadvantage that they do not retain the paste in the positive as well as the previously used wood separators since particles of paste tend to slide down their smooth surfaces instead of adhering to it. Furthermore, such separators are expensive to manufacture as compared with the cost of wood separators and frequently are of larger volume than the wood separators, thus reducing the space available for free acid between the plates and hence reducing the capacity of the battery.

It has further been proposed to bond glass fibres or glass wool to wood separators or to partially porous boards or plates of cellulose fibres, the bonding being effected by means of adhesives. The processes of manufacture of such separators has involved the separate manufacture of glass wool sheets, and separators, and subsequent operations to bond them together, which has resulted in a lengthy and expensive operation.

It is an object of the present invention to provide an improved method of manufacturing separators for batteries, which will enable such separators to be more rapidly and inexpensively made than hitherto, and which will produce separators which will overcome the above mentioned disadvantages, and which will have good paste retaining properties, as well as satisfactory insulation properties whilst at the same time having a small effective volume so that the amount of acid in the battery may be as large as or even larger than that usual with wood separators in batteries of similar proportions.

According to the present invention there is provided a method of manufacturing battery separators comprising the steps of coating a sheet of glass fibres or the like to a substantially uniform thickness with plastic material in finely divided form and then subjecting the coated sheet to the action of heat sufficient to cause the particles of plastic material to coalesce and bond with the glass fibres or the like to form a composite porous plate.

Amongst suitable plastic materials which may be used according to this invention are powdered rubber, polyvinyl chloride, copolymer of polyvinyl chloride, polyvinyl acetate, polyvinylidine chloride, polystyrene, methyl methacrylate.

It is important that the plastic material should be in a finely divided form and we prefer to use such materials as will pass an 80—100 mesh sieve, although such materials as would pass a 200 mesh sieve may be used.

After coating with the said finely divided plastic material, the fibres are subjected to heat for instance by being passed through an oven at a temperature which is sufficient to soften the plastic particles and to sinter them so that they coalesce into a solid body with

spaces remaining between the particles to give the necessary porosity, whilst at the same time bonding firmly to the glass fibres to form a composite separator having a fibre paste retaining mat, also serving as an acid holding sponge, on one side, and a porous plastic insulating plate on the other side. Particles of plastic tend to penetrate the fibres and prevent their collapse under moderate pressure, so as to function as a sponge when inserted in a battery.

The actual temperature and heating time will vary in accordance with the plastic material used and in the case of one brand of finely powdered polyvinyl chloride we have found that satisfactory results may be obtained by heat treatment at between 180° C. and 220° C. for about 5—15 minutes.

The coating of the fibres with the plastic material may be carried out in any convenient manner and we have found it advantageous to pass the fibres under a vibrating distributor such as a sieve or to deliver the powder from one moving conveyor onto the fibres as they pass under such conveyor on another conveyor. Means may be provided for controlling the amount of powder coated onto the fibres to a substantially uniform thickness and if desired a doctor blade or blades may be used for this purpose and/or a comb may be employed to give a ribbed surface. Before coating it is desirable that the plastic material be thoroughly washed and dried to remove any impurities therefrom.

The said fibres may be of glass, conveniently in the form of sheets of glass wool or glass silk or they may if desired, be loosely woven into a mat of any desired length. The fibres alternatively may be themselves of plastic materials, e.g. polyvinyl chloride, polystyrene or polythene, such materials being conveniently extruded in monofilament form and subsequently cut up and matted, it being understood that such materials must have adequate resistance to acid.

It is important that the finished separators shall retain acid when in use and to this end the fibres should have a sufficient rigidity and resistance to acid to prevent them being compressed and flattened in a battery. These properties will to a certain extent be imparted to the fibres during the coating and heating process according to the invention. It may however be desirable to impart additional stiffness to the fibres, and such additional stiffness may be provided by incorporating an acid insoluble binder in the fibres and amongst suitable binder substances may be mentioned artificial resins such as phenol formaldehyde, polyvinyl chloride, polystyrene, methyl methacrylate.

Such substances will be incorporated in the glass fibres before the said plastic material is coated thereon. The substances may be applied in powder form or in solution. Where they are applied in powder form, the binder is preferably applied from a vibrating distributor and if desired the glass fibres themselves may be on a vibrating carrier in order to facilitate adequate penetration of the binder into the interstices of the fibres. The powdered binder can then be cured by a heat treatment, which may in some cases be carried out at the same time as the heat treatment of the coated fibres according to the invention, or may be a separate prior treatment.

In another method of giving additional stiffness the pretreatment may be carried out by passing the glass fibres in a mat or sheet through a bath of a solution of the selected binder and then curing it in an oven in a manner known per se. If desired we may effect the pretreatment by spraying the glass fibres with a solution of the selected binder.

In some cases a glass silk may be treated according to the present invention and thereafter may be passed through a bath of a solution of a suitable resin binder followed by a rapid curing oven in order to give additional rigidity to the separators which will be finally formed. This method of providing strengthened separators is in some respects preferred to the use of a pretreated resin bonded glass silk since the latter are difficult to keep flat during treatment when applying the powder substance according to the invention. An unbonded glass silk is easily maintained flat and is thus in that respect more satisfactory.

A method of increasing the stiffness of the fibre sheet in the finished separators is to perforate said sheet before application of the plastic material, these holes then being filled by the plastic material during coating so that in the finished separators areas corresponding to those of the perforations are formed of continuous plastic material, in effect providing studs or keys extending through the fibre sheet. In an extension of this method the perforations are formed by dividing the fibre sheet into strips which are held in spaced relation during coating, so that ribs of continuous plastic material are formed in the finished separators, such ribs being relatively narrow, e.g. $^1/_{16}$" wide. Alternatively small cuts may be made in the fibre sheet, to allow formation of small plastic keys.

If in any instance it is desired to produce a separator plate according to the invention of higher porosity, we may incorporate one or more gas forming substances in the plastic material before it is spread on the glass fibres. Such substances will be intimately mixed with the powdered plastic material and for this purpose we may for instance use sodium carbonate, sodium bicarbonate, lead carbonate, diazo-amino-benzene. We have

found that amounts of gas forming substances from 2—30% by weight of the plastic material may be used according to the degree of porosity required.

We prefer to subject the sintered plates to a washing treatment to remove any impurities due to partial decomposition of the plastic material and if desired a small quantity of say .1% of a wetting agent may be incorporated in the washing medium to facilitate penetration.

In order that the invention may be well understood preferred examples by way of illustration only will now be described in further detail, referring to the accompanying drawing which shows diagrammatically an apparatus for manufacturing battery separators by a method embodying the present invention.

A sheet 1 of glass fibres in the form of loosely woven glass silk is fed from a roll 2 of such material between two felt-covered rollers 3, the lower roller 3 of which dips into a water trough 4 so that the sheet 1 is damped as it passes said rollers. Then said sheet 1 is fed under pick-up rollers 5 to an endless conveyor belt 6 carried on drums 6a, along which it passes to a hot press roller 7, preferably at about 100° C., which removes the dampness applied by rollers 3 and simultaneously removes any wrinkles from the sheet 1, which should be as flat and free from wrinkles as possible before the further treatment commences.

Continuing along conveyor belt 6, the sheet next, after passing a feed roller 8, comes to a vibrating sieve 9 supplied from above with powdered polyvinyl chloride (PVC), which is shaken by said sieve 9 on to the sheet 1. As the sheet 1 moves on, it passes a doctor blade 10 which ensures uniformity of the thickness of the PVC powder coating as the sheet enters an oven 11 over the belt. The oven 11 is maintained at a temperature of about 200—220° C., and the length of said oven and the conveyor belt speed are such that the passage of any part of the sheet 1 through the oven 11 takes sufficient time for the particles of PVC to be completely sintered together without being burnt. Upon emerging from said oven 11, the sheet 1 passes under further feed rollers 12, is subjected to a cooling air blast as indicated by arrow 13, and then removed from the conveyor belt by a scrape-off knife 14.

After leaving the conveyor belt, a length of sheet is allowed to hang slack between the scrape-off knife 14 and a feed mechanism such as a pair of rollers 15 which feed the sheet towards a stop 16. As the sheet 1 engages the stop a guillotine 17 operates to sever a desired length of sheet corresponding to the length of separator required, and the severed length drops into a collecting box 18, as indicated at 19. The length of sheet cut depends upon the spacing of the stop 16 and guillotine 17, either of which may be made adjustable if it is required to permit variation of the length of sheet.

In another form of the invention, the glass fibre sheet is dipped in a solution of phenol formaldehyde and cured in an oven before receiving the powdered PVC or other plastic material, which may be applied by a second conveyor belt depositing such powder at an appropriate place. Alternatively, the phenol formaldehyde may be applied and curing effected after application of the powder and sintering, suitable apparatus being disposed between the oven 11 and guillotine 17.

Thus it will be seen that we have provided a method of manufacturing improved separators for batteries in a rapid and less expensive manner than hitherto since the manufacture of the insulating portion thereof and its bonding to the retainer mat can be carried out in a single step without the need for the separate manufacture of both parts and their subsequent attachment together.

It will be understood that we have only described preferred examples of an invention by way of illustration above and that variations and modifications may be made therein without departing from the scope of the invention, thus for instance we may if desired have two or more layers of glass fibres bonded together by means for example of a phenol formaldehyde binder upon which a sintered backing is formed in the manner indicated. Furthermore, we have found that separators made according to this invention may be incorporated with advantage in electrode envelopes such as are described for instance in our Specifications Nos. 448,468 and 632,061.

What we claim is :—

1. A method of manufacturing battery separators comprising the steps of coating a sheet of glass fibres or the like to a substantially uniform thickness with plastic material in finely divided form and then subjecting the coated sheet to the action of heat sufficient to cause the particles of plastic material to coalesce and bond with the glass fibres or the like to form a composite porous plate.

2. A method as claimed in Claim 1, in which said plastic material is such as will pass an 80—200 mesh sieve.

3. A method as claimed in Claim 1 or Claim 2, in which said plastic material comprises one or more of the following : powdered rubber, polyvinyl chloride, copolymer of polyvinyl chloride, polyvinyl acetate, polyvinylidene chloride, polystyrene and methyl methacrylate.

4. A method as claimed in any of Claims 1 to 3, in which the fibre sheet is treated with an acid insoluble binder.

5. A method as claimed in Claim 4, in which said binder also comprises plastic material in finely divided form, the binder treated sheet being heated to cure the plastic binder material.

6. A method as claimed in Claim 4 or Claim 5, in which said binder is composed of one or more of the following materials: phenol formaldehyde, polyvinyl chloride, polystyrene, and methyl methacrylate.

7. A method as claimed in Claim 5, in which the curing of the binder material is effected at the same time as or after the coated fibre sheet is heated to coalesce the particles of the plastic material coated thereon.

8. A method as claimed in any of Claims 4 to 7, in which said binder is applied in solution.

9. A method as claimed in Claim 8, in which said binder is applied by spraying.

10. A method as claimed in any of the preceding claims, in which said sheet of glass fibres or the like is perforated before coating the plastic material thereon, whereby in the finished separators areas corresponding to those of the perforations are formed of continuous plastic material, providing studs or keys extending through the fibre sheet.

11. A method as claimed in Claim 10, in which said perforations are formed by dividing the fibre sheet into strips, said strips being held in spaced relation during coating, whereby relative narrow ribs of continuous plastic material are formed in the finished separators.

12. A method as claimed in any of the preceding claims, in which the coated sheet is washed after the application of heat thereto.

13. A method as claimed in Claim 12, in which a small quantity of a wetting agent is incorporated in the washing medium.

14. A method as claimed in any of the preceding claims, in which the sheet of glass fibres or the like is damped and hot-pressed to remove wrinkles therefrom, prior to coating the plastic material thereon.

15. A method as claimed in any of the preceding claims, in which said fibres comprise a plastic material, extruded in monofilament form and subsequently cut up and matted.

16. A method as claimed in Claim 15, in which said plastic material consists of one or more of the following: polyvinyl chloride, polystyrene and polythene.

17. A method as claimed in any of the preceding claims, in which a gas forming substance is incorporated in the said plastic material before applying it to the fibres in order to increase the porosity of the separator.

18. A method as claimed in Claim 17, in which from 2—30% by weight of sodium carbonate, sodium bicarbonate, lead carbonate or diazo-amino-benzene is incorporated as the gas forming substance.

19. Battery separators produced by a method as claimed in any of the preceding claims.

20. Batteries incorporating one or more separators as claimed in Claim 19.

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PROVISIONAL SPECIFICATION.

Improvements in or relating to the Manufacture of Electric Battery Separators.

We, YOUNG ACCUMULATOR COMPANY LIMITED, a British Company, of Burlington Works, Malden Way, New Malden, Surrey, do hereby declare this invention to be described in the following statement:—

This invention is concerned with improvements in or relating to the manufacture of separators for electric storage batteries.

Separators between the positive and negative plates of storage batteries have been made of wood which whilst satisfactory in some respects, tends to dry out, shrink or crack and causes damage to the plates if the battery is stored in a dry condition. Separators of rubber, and various plastic substances have been proposed to overcome this disadvantage and whilst they are not so liable to damage the plates, they suffer from the disadvantage that they do not retain the paste in the positive as well as the previously used wood separators since particles of paste tend to slide down their smooth surfaces instead of adhering to it. Furthermore, such separators are expensive to manufacture with respect to the cost of wood separators and frequently are of larger volume than the wood separators, thus reducing the space available for free acid between the plates and hence reducing the capacity of the battery.

It is further been proposed to bond glass fibres or glass wool to wood separators or to partially porous boards or plates of cellulose fibres, the bonding being effected by means of adhesives. The processes of manufacture of such separators has involved the separate manufacture of glass wool sheets, and

separators, and subsequent operations to bond them together, which has resulted in a lengthy and expensive operation.

It is an object of the present invention to provide an improved method of manufacturing separators for batteries, which will enable such separators to be more rapidly and inexpensively made than hitherto, and which will produce separators which will overcome the above mentioned disadvantages, and which will have good paste retaining properties, as well as satisfactory insulation properties whilst at the same time having a small effective volume so that the amount of acid in the battery may be as large as or even larger than that usual with wood separators in batteries of similar proportions.

According to the present invention there is provided a method of manufacturing battery separators comprising the steps of coating a sheet of glass fibres to a substantially uniform thickness with plastic material in finely divided form and then subjecting the coated sheet to the action of heat sufficient to cause the particles of plastic material to coalesce and bond with the glass fibres to form a composite porous plate.

Amongst suitable plastic materials which may be used according to this invention are powdered rubber, polyvinyl chloride, copolymer of polyvinyl chloride, polyvinyl acetate, polyvinylidine chloride, polystyrene, methyl methacrylate.

It is important that the plastic material should be in a finely divided form and we prefer to use such materials as will pass an 80—100 mesh sieve.

After coating with the said finely divided plastic material, the glass fibres are subjected to heat for instance by being passed through an oven at a temperature which is sufficient to soften the plastic particles and to sinter them so that they coalesce into a solid body with spaces remaining between the particles to give the necessary porosity, whilst at the same time bonding firmly to the glass fibres to form a composite separator having a glass fibre paste retaining mat on one side, and a porous plastic insulating plate on the other side. The actual temperature and heating time will vary in accordance with the plastic material used and in the case of one brand of finely powdered polyvinyl chloride we have found that satisfactory results may be obtained by heat treatment at between 180° C. and 220° C. for about 5—15 minutes.

The coating of the glass fibres with the plastic material may be carried out in any convenient manner and we have found it advantageous to pass the fibres under a vibrating distributor such as a sieve or to deliver the powder from one moving conveyor onto the glass fibres as they pass under such conveyor on another conveyor. Means may be provided for controlling the amount of powder coated onto the glass fibre to a substantially uniform thickness and if desired a doctor blade or blades may be used for this purpose.

The said glass fibres may be in the form of sheets of glass wool or glass silk or they may if desired, be loosely woven into a mat of any desired length.

It is important that the finished separators shall retain acid when in use and to this end the glass fibres should have a sufficient rigidity and resistance to acid to prevent them being compressed and flattened in a battery. These properties will to a certain extent be imparted to the glass fibres during the coating and heating process according to the invention. It may however be desirable to impart additional stiffness to the glass fibres, and such additional stiffness may be provided by incorporating an acid insoluble binder in the glass fibres and amongst suitable binder substances may be mentioned artificial resins such as phenol formaldehyde, polyvinyl chloride, polystyrene, methyl methacrylate.

Such substances will be incorporated in the glass fibres before the said plastic material is coated thereon. The substances may be applied in powder form or in solution. Where they are applied in powder form, the binder is preferably applied from a vibrating distributor and if desired the glass fibres themselves may be on a vibrating carrier in order to facilitate adequate penetration of the binder into the interstices of the fibres. The powdered binder can then be cured by a heat treatment, which may in some cases be carried out at the same time as the heat treatment of the coated fibres according to the invention, or may be a separate prior treatment.

In another method of giving additional stiffness the pretreatment may be carried out by passing the glass fibres in a mat or sheet through a bath of a solution of the selected binder and then curing it in an oven in a manner known *per se*. If desired we may effect the pretreatment by spraying the glass fibres with a solution of the selected binder.

If in any instance it is desired to produce a separator plate according to the invention of higher porosity, we may incorporate one or more gas forming substances in the plastic material before it is spread on the glass fibres. Such substances will be intimately mixed with the powdered plastic material and for this purpose we may use for instance sodium carbonate, sodium bicarbonate, lead carbonate, diazo-amino-benzene. We have found that amounts of gas forming substances from 2—30% by weight of the plastic material may be used according to the degree of porosity required.

We prefer to subject the sintered plates to

a washing treatment to remove any impurities due to partial decomposition of the plastic material and if desired a small quantity of say .1% of a wetting agent may be incorporated in the washing to facilitate penetration.

In order that the invention may be well understood preferred examples by way of illustration only will now be described in further detail.

A sheet of glass silk in loosely woven form is placed on a flat surface and a coating of powdered polyvinyl chloride which passes an 80—100 mesh sieve is distributed uniformly over the glass silk from a vibrating sieve. When the glass silk is substantially uniformly coated to the desired thickness it is transferred to an oven and heated at about 200° C. for ten minutes, whereupon the individual particles sinter together at their edges to form a solid body which has however spaces or interstices to give it the desired porosity. At the same time the particles also bond themselves firmly onto the glass silk without the need of any intermediate adhesive thus forming a separate plate having a glass silk portion which serves as a paste retaining mat and also is capable of retaining the maximum volume of acid on a positive plate, and a less porous and thin backing material which serves to prevent short circuits and which due to its small solid volume enables a large volume of acid to be kept in the battery.

In another example according to the invention glass silk in loosely woven form is dipped in a solution of phenol formaldehyde and cured in an oven and is thereafter placed on a moving conveyor. Above the said conveyor, a second conveyor is provided which distributes powdered plastic material on to the cured and bonded glass silk. A doctor blade is provided to control the thickness and uniformity of the coating on the glass silk and thereafter the first mentioned conveyor carries the coated glass silk through an oven at a temperature appropriate for carrying out the above mentioned sintering process.

Thus it will be seen that we have provided a method of manufacturing improved separators for batteries in a rapid and less expensive manner than hitherto since the manufacture of the insulating portion thereof and its bonding to the retainer mat can be carried out in a single step without the need for the separate manufacture of both parts and their subsequent attachment together.

It will be understood that we have only described preferred examples of an invention by way of illustration above and that variations and modifications may be made therein without departing from the scope of the invention, thus for instance we may if desired have two or more layers of glass fibres bonded together by means for example of a phenol formaldehyde binder upon which a sintered backing is formed in the manner indicated. Furthermore, we have found that separators made according to this invention may be incorporated with advantage in electrode envelopes such as are described for instance in our Specifications Nos. 448,468 and 632,061.

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679,514 COMPLETE SPECIFICATION

1 SHEET

This drawing is a reproduction of the Original on a reduced scale.